Implementing TouchMe Paradigm with a Mobile Phone

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Abstract

In earlier papers, the concept of Physical Browsing has been suggested as a natural way to improve the usability of mobile devices and to enable interaction with digital services associated with real world objects in the environment. Since mobile phones are very widely used, it offers a good platform for pervasive applications. In this paper, we realize the Physical Browsing concept using an RFID-reader. With the reader attached to the mobile phone, we invoke digital services embedded in the environment. The implementation of the software needed for ubiquitous use of physical browsing is presented and the feasibility is demonstrated with four concrete examples.

1. Introduction

Many real world devices, objects or locations have mental associations to digital services. For example, we associate a phone number in a business card to the act of making a phone call; we associate a printed web address in an advertisement to the act of opening the web page in a browser; we associate two Bluetooth enabled devices with each other when we want to exchange data between them. Using this association in the Human Computer Interface has not been possible (or even relevant) in the classic WIMP paradigm, where interaction mainly takes place at the desktop. Data entry occurred by typing, feedback and manipulation was provided by "classic" Graphical User Interface tools and the computer was tied to a certain physical location, the desk. However, since mobile computing has become commonplace due to the vast number of cellular phones[1] and laptops in use, employing the mental association between digital services and their real world counterparts is becoming more lucrative.

Mobile devices offer a potential means to technically realize the mental association between the digital services and their real world counterparts. Context awareness, especially when using location information is a major effort towards this goal. Dey [3] gives the following definition for context: "Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves." And he goes on to define a context-aware system as a system which "uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task." These definitions indicate the implicit and autonomous nature of context awareness. Requirement for autonomous action makes designing robust and user-accepted context aware applications a challenging task.

A different approach is to use the association between digital services and their real world counterparts explicitly. This approach is taken in the concept of Physical Browsing [9]. Ideas akin to physical browsing have been proposed previously in Xerox tags, a system, which the creators describe as "bridging physical and virtual worlds" [10]. The system combines RFID tags and readers, RF networking, infrared beacons and portable computing. In the Cooltown project [5], users could collect links (URLs) from infrared beacons attached to physical objects like walls, printers, radios, pictures and others. Cooltown's user interaction theme is based on adding hyperlinks on physical locations. In addition, barcodes can be used to transfer information between physical objects and mobile devices. The user reads the barcodes with a wireless reader and the code is sent to a server. The server then transmits the information about tagged object to the user's cell phone, email, or some other information application or device.

Bowman and Hodges [2] have studied interaction in virtual environments whereas for example Mazalek et al. [7] have created tangible interfaces. Our paradigm lies somewhere between these two approaches, combining physical and virtual. Using barcodes as bookmarks for the web in a schema called Webstickers has been proposed [6]. Special visual codes adapted to be readable by camera phones, have been introduced and commercialized in Japan (the QR or Quick Response code) and in Europe, where SpotCode [8] as a tool to transform a camera phone into a innovative user interface has been introduced.

The concept of *Physical Browsing* supports three user interface paradigms: ScanMe, PointMe and TouchMe [9].

- *ScanMe* When a user enters a space, he can use his mobile device to scan the environment for tags. The services provided by the tags will then be presented on the User Interface (UI) of the device. Thus the presence of the tags is communicated to the user and he can then choose the tag (object) of interest with the mobile device. Effectively, this means choosing a physical object in the digital world.

- *PointMe* In PointMe paradigm, the user can point and hence choose a tag with a mobile device, which has an optical beam, e.g. infra red or laser, for pointing. The PointMe paradigm may be implemented solely by means of the optical beam, or by combinations of optical and RF communication technologies. In the latter case, the optical mechanism is used for choosing the tag while the RF communication is used from tag to mobile device communication. We have implemented the PointMe paradigm by using the infrared communication capability of a hand held computer and a special infrared tags for environmental sensor reading [1] and other actions.

[1] 684 million mobile phones were sold in 2004 and the number is expected to grow to 735 million in 2005 http://www.itfacts.biz/index.php?id=P2558

- *TouchMe* In the TouchMe paradigm, the tag (object) of interest is chosen by (virtually) touching it with a mobile device. Like pointing, touching requires that the user identify the location of the tag. However, the tag itself does not necessarily have to be visible. Touching is an unambiguous way to select the right tag and object. Typically, it is the most powerful paradigm in the case where a multitude of objects is close to each other, e.g. in a supermarket for downloading product information

There is a growing interest in the use of RFID (Radio Frequency Identifier) tags, partly due to strong academic and industrial alliances, most notably the Electronic Product Code[1] and Near Field Communication (NFC) Forum[2]. Tag readers are being integrated into mobile devices [4], and a mobile phone manufacturer has introduced a mobile phone with an NFC compatible RFID reader[3]. We have analyzed the benefits and drawbacks of various tag technologies and their potential for the Physical Browsing concept [1]. Based on this analysis and the rapid spread of RFID technology - including the integration of RFID reader to mobile phones, we see TouchMe as a very potential approach.

In this paper we present a realization of the TouchMe concept and analyze the feasibility of the paradigm with four example applications. Furthermore, we present a software platform for implementing the paradigm in a mobile phone. User studies are outside the scope of this paper and remain for future work.

2. Platform

In this section our hardware and software platform is described. The guiding principle for platform selection was to make the system robust and commercial-like to make possible to evaluate the use of tags in real life situations.

2.1. Hardware

A Nokia 6600 smart phone was used as implementation platform. Nokia 6600 was the most advanced model using the popular Series 60 Symbian platform available when the selection was made. It runs the Symbian operating system, which allows access to various APIs (Application Interfaces) in the C++ language allowing the exploration of various Physical Browsing scenarios.

A prototype RFID reader is attached to the phone by replacing the battery cover (Figure 1a). The reader draws power from the phone battery eliminating the need for another power source. The reader antenna surrounds the camera lens without hindering the use of it.

The RFID reader is connected to the mobile phone via wireless Bluetooth connection, since Nokia 6600 models do not feature any documented wired communication channels. The reader and the Bluetooth connection to the phone is activated and deactivated by pressing a button located on the RFID cover. Turning the reader off after use is necessary since the Bluetooth connection and RF-reader consume much power and deplete the battery in less than a day. When the reader is activated and the Bluetooth connection established, tags can be read without any button presses or actions other than the touching gesture made with the phone. Although the design of the device is proprietary it shares many common features with NFC-devices.

a) b)

Figure 1. Nokia 6600 phone with RFID reader attached (a) and a Bluetooth barcode reader pen (b).

Tags used with the prototype can accommodate 62 characters, i.e. most URLs (Universal Resource Locator) fit into the tag. After the reader is started, latency in the communication and data transfer with the tag is negligible making the touch action very easy and convenient to use.

Due to ubiquity of barcodes a commercial barcode reader pen made by Baracoda was added to the hardware selection (Figure 1b). The pen uses Bluetooth to connect to the phone. Both the RFID reader and the barcode pen can be used simultaneously.

2.2. Tag Manager

In [4] we outlined requirements and design principles for a phone located middleware component called Tag Manager. In this section the current implementation of the Tag Manager is described. Tag Manager fulfills the following main requirements:

- Tag Manager provides an interface for tag readers, so that different tag readers, either software based or software and hardware based can be attached to the phone and possibly used simultaneously.
- Tag Manager allows multiple applications or services from different vendors to co-exist in the same phone and even use the same tags. This feature is important in order to allow the existing tag infrastructure to be reused when new services are created.
- Applications or services using the tags can be implemented to work without any network connections. This is important since not all services require network connections and repositories can be made local, in case network bandwidth is considered to be too expensive. However network based service discovery mechanisms can be implemented on top of the Tag Manager.

[1] http://www.epcglobalinc.org/
[2] http://www.nfc-forum.org/
[3] http://press.nokia.com/PR/200411/966879_5.html

- The Tag Manager limits the user interface design as little as possible. Visual outlook is important in many applications, such as games, which makes replaceable selection menu component an important feature.

The Tag manager and its relation to different software and hardware components is presented in Figure 2. The components drawn with dashed lines are either not currently implemented or modified to make use of the Tag Manager.

The Tag Manager is implemented as a Symbian server. It is typically loaded when one of the tag readers is started. Tag readers connect to the Tag Manager via the Symbian inter process communication (IPC) mechanism and feed the contents of the tag to the manager whenever a tag is read.

The RFID reader provides its own hardware based user interface for tag reading and no UI functionality of the phone is needed. In this case the tag reader software is implemented as a background process connected to the Tag reading hardware.

Software-based readers, such as a matrix code reader utilizing the built-in camera of the phone, typically utilize the phones own user interface and can be implemented as normal applications.

Applications and services can be attached to the Tag Manager in two ways: The first is by using dynamic DLLs called TagConsumer plugins, also called starters. The second way is that applications already running connect to the Tag Manager by using the Symbian client-server approach. The first way is currently implemented.

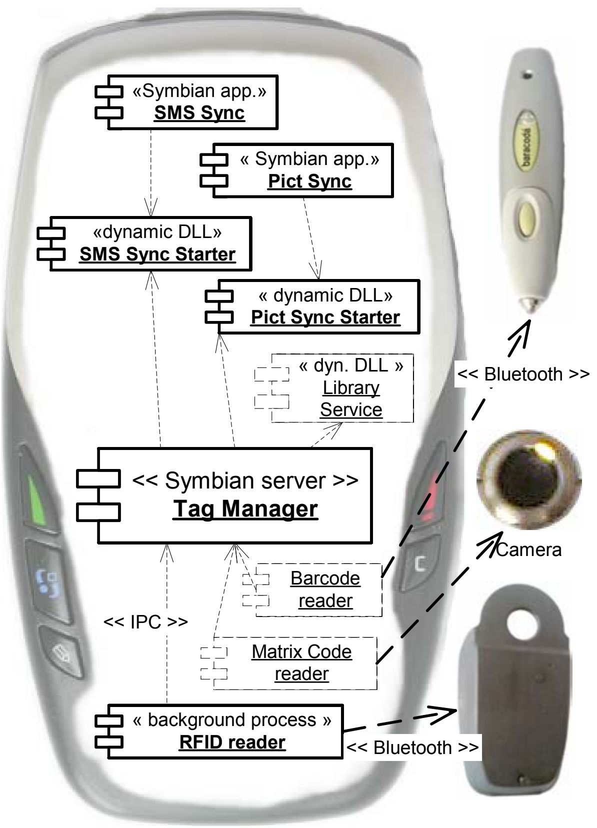

Figure 2: Deployment diagram of Tag Manager

TagConsumer plugins implement a TagConsumer interface (Figure 3). Whenever a tag is read the Tag Manager calls each plugin's GetPriority -method which takes the tag contents as parameter and returns the priority for this plugin.

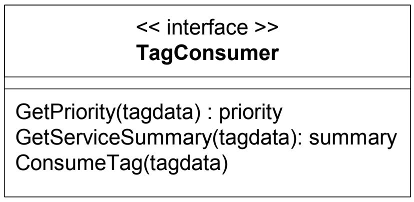

Figure 3. Tag Consumer interface, implemented by all services.

The GetPriority-method checks whether the tag is of the correct type for this service and whether the user is currently using this service. That is, it checks whether the service is on the foreground. A priority based on this is returned:

- *Cannot consume* - The tag cannot be used by this service.
- *Ready to consume* - The tag can be used by this service, but the service is not in active use.
- *Active consumption* - The tag can be used by the service and the user is actively using the service.

The Tag Manager selects the plugin with the highest priority and calls its ConsumeTag -method. It is assumed that only one service will return an *active consumption* -priority. If multiple plugins have a *ready to consume* –priority, a list of services is presented to the user (Figure 4).

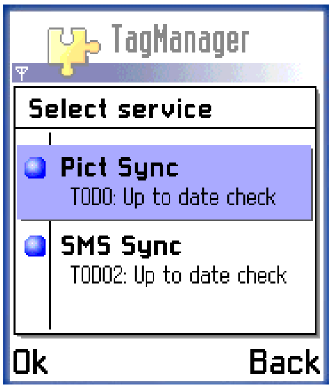

Figure 4. Selection of service associated to a tag.

The GetServiceSummary -method is used to get information for the list. The summary can be generated on the fly taking advantage of the current tag contents. A quick local database query can be performed to display service related information for the tag. This has not yet been implemented by the services, as presented in Figure 4.

The Tag Manager launches the selected service by calling the ConsumeTag-method. Typically the application providing the service is launched and it is made visible to the user. The ConsumeTag-method can also launch existing applications like the XHTML (Extensible HyperText Markup Language) browser of the phone.

3. Applications

Several demonstration applications have been implemented to test the feasibility of the TouchMe paradigm of the Physical Browsing concept. In general, all examples fit well the concept idea, making the use of the applications easy and ubiquitous. The platform presented in chapter 2 was tested with the SMS and Picture synchronization applications. The other applications can also be easily modified to use the platform.

3.1. SMS & Picture Synchronization with PC

Two applications with similar characteristics were built to evaluate the TouchMe paradigm in device to device communication: SMS Sync application sends all new SMS messages from the phone to the PC when a RFID tag attached to the PC is touched (Figure 5). Similarly the Picture Sync application sends all new photos taken with the phone built-in camera to the PC. Both applications use the same RFID tag which provides a test for the Tag Manager’s service selection properties described in section 2.2: if the phone is in the basic state, an application selection list of Figure 4. is presented and if one of those two applications are visible to the user the tag is passed to this application.

The RFID tag attached to the PC contains the unique Bluetooth address of the PC Bluetooth adapter. The standard Bluetooth Object Exchange (OBEX) protocol is used for transmission; hence no special software for the PC is needed. Both applications also keep track which messages or pictures are sent to which computer.

Figure 5. SMS messages are sent to the PC by touching the RFID tag.

3.2. Phone Call from Business Card

A tag attached to the business card serves as a convenient shortcut for calling. The RFID tag attached to the business card contains the phone number and is used by the caller application to launch the phone call. Also pictures of friends and relatives could be used for phone call initiators.

3.3. Mobile Payment

Mobile payment was also explored with a mock up application. A vending machine with an option to order soda by calling a certain number was equipped with an RFID tag (Figure 6). The tag contained a phone number of the service. Using the tag with the TouchMe paradigm removed the need to punch in the phone number and open the call. The tag-augmented vending machine was perceived to be easy to use without the additional hassle of looking up and keying in the phone number.

Figure 6. Soft drink is ordered by touching RFID tag.

3.4. Book Availability in Library

The barcode reader was also tested alongside the RFID reader. A barcode containing the ISBN (International Standard Book Number) number of a book was read with the Baracoda barcode pen (Figure 7).

Figure 7. ISBN barcode in a book offers a link to a university library database.

The scanning launches the factory installed XHTML browser of the phone and gives it a URL containing a query to a local university library database. A page containing book availability information in the library is returned.

4. Discussion

One of the promises of the TouchMe approach is to speed up interaction. However, in the prototypes presented in this paper, the wireless connection to the RFID and barcode readers did not come without downsides: It takes about 18 seconds to start the reader and establish a Bluetooth connection between the reader and the phone before the first tag can be scanned. That is clearly too much for convenient ad-hoc use of the reader and destroys the user experience in real life situations. The barcode pen takes a bit different approach for establishing the Bluetooth connection, but still the total time for preparing the scan of the first tag is about same, over 15 seconds.

The time of the first scan could be dramatically reduced by integrating the reader into the phone by using a wired connection. A wired connection would enable the reader to be on all the time and enable instant recovery from power saving state. This is the approach taken by Nokia with the NFC replacement cover published for their 3220 model. Unfortunately, when building our prototype we did not have access to documented wired interfaces of the selected phone model.

After the startup time, the use of readers was easy and convenient although scanning barcodes with the Baracoda barcode pen demands some practice.

The ability to read barcodes with a camera phone, would make the huge wealth of information embedded in the European article numbering (EAN), Universal product codes (UPC) and ISBN codes available to mobile users, as demonstrated by the book availability example in section 3.4. Unfortunately, fixed focus optics used in most camera phones does not allow sufficiently good enough close up images of barcodes for them to be interpreted. Some phone models have an extra lens accessory for making the focal length shorter for close-up pictures but having to attach the accessory for barcode reading might not be very convenient.

The number of applications that can be used with the TouchMe paradigm is immense. Associations between the tagged object and service provided by touching the tag play a big role in the user experience. Especially since users may have a different conception about what should happen when certain object is touched with a mobile phone. The demonstrated applications try to capture the most obvious association with varying success.

- *SMS and picture synchronization* The tag was attached to a laptop. The services that could be offered by the laptop computer or the phone are numerous, but the mental association was to create a connection between the phone and the computer and in this case two services were offered for selection.
- *Phone call form business card* Perhaps the most obvious and natural association between the mobile phone and business card is phone call to the person in question, although one might want to transfer the card information to the phone for later use, or start writing a text message to the person.
- *Mobile payment with RFID reader* In this demonstration the tag was attached to the vending machine with only a simple logo marking the tag. In payment applications the user should be able to be sure what happens when the tag is touched. Payment information should be readable near the tag, or it should have a distinct and well known logo to separate it from other applications. Also an extra confirmation should be done, before the actual transaction is made.
- *Book availability in library* The association with the library service and the ISBN barcode is not very obvious. Other uses for the barcode could be, for example, pricing information from the internet bookstore, or the official web pages of the book. The application can be used conveniently with the selection feature introduced by the Tag Manager and the possibility to connect the tag with the service only when the service application is running.

The original intention of the Physical Browsing paradigm is the easy use of mobile services by having one service launched from one tag. This approach is intuitive and works well with the mobile phone and RFID tags. In some cases, it seems that several services should be used from one tag. Space constraints in the real world objects might limit the number of tags that can be placed on products. Also the price of the tag limits the possibilities. The multiple selection menus are in contradiction with the paradigm, and use of them should be made as scarce as possible. It might be ideal, if the user behavior or context awareness could be used to make a pre-selection when the menu is used. That way, the user might be saved from browsing through the menu, thus minimizing the key presses.

When compared to traditional tags, such as basic barcode tags, RFID and visual matrix code tags have much more data storage space. Larger storage space opens up many possibilities which are not practical with barcodes for example. In the case of device to device communication information needed by alternative connection methods could be stored into one tag. A larger memory would enable the use of markup languages and possibly even program code to be entered into tags. Standardization of tag contents will become an issue because services, phones and tags have to be compatible if large scale deployment is wanted.

The used prototype tags could accommodate 62 characters, which is sufficient for most URLs and unique identifiers, but not sufficient for longer URLs or other detailed information that could be read from the tag.

Differences between tags' content sizes, lack of tag content standards and difficulties to predict future tag use models lead to the decision to make the Tag Manager as simple as possible. Functionalities, such as security, were left for the applications or above software layers. The flexibility of our approach will be tested when we move on to more complex applications.

5. Conclusions

Although main use of RFIDs and barcodes is seen in the domain of logistics, they can also be useful as an important part of natural interfacing between humans and ubiquitous services accessed via mobile devices.

Demonstrations show how tags can be used to invoke actions, such as placing a phone call, performing information retrieval or mobile payment. In some cases it is viable to have a possibility of having several services available by touching one tag, instead of one service per tag. This behavior is demonstrated with SMS and Picture synchronization applications. The Tag Manager enables linking multiple services to a single tag. This makes it possible to create personalized services without the need to produce a separate tag for each user (with her preferences). This approach combines a cost effective solution for providing the tag infrastructure and personalized services.

Instant availability of the service is one key factor of the ubiquitous use of mobile services. The long startup time consisting of starting the scanners and establishing the wireless connections prevents the use of the prototype in real life use. Integration of the reader to the mobile phone should solve the startup delay problem in the prototype.

The TouchMe paradigm is one of the central paradigms of the physical selection concept. In this paper a software platform implementation is presented and some application scenarios demonstrated for the paradigm. With the selected example scenarios, we have demonstrated the feasibility of the TouchMe paradigm in a mobile phone. User studies are going on and their results will be reported in future papers.

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